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**MAN-MACHINE INTERACTION IN THE  
ALTERNATE V/H SUBSYSTEM**

**PURPOSE:**

This memorandum states the goals, requirements and assumptions concerning operator contribution to a manual V/h input.

**GOALS:**

To provide an alternate V/h (velocity/height) computation for use in other subsystems. A 2% standard deviation from true V/h is a design objective. No significant advantage is to be gained by trying to improve on this objective.

**METHODOLOGY**

It has been proposed that the operator sight thru his periscope and indirectly measure the apparent angular velocity of ground objects by measuring the time it takes for an object to travel thru a known angle. The method proposed is to press a button when a selected object crosses line A and either another or the same button when it crosses line B. A preliminary tolerance analysis reveals that the dominant error terms are operator error (variability in response time, positioning, uncertainty of object) and pitch variations due to "phugoid" as the distance between line A and line B increases the percent error due to the above decreases. Appendix I shows a tentative tolerance analysis.

**GROUND RULES:**

We have been informed that any scheme for improving operator accuracy such as "aided tracking" which requires significant changes

in the periscope or auxiliary equipment cannot be considered. We also understand that an optimum solution provides the necessary accuracy while requiring the shortest duration of operator attention possible.

#### HUMAN ENGINEERING

For proper man-machine integration the following questions are among those that should be answered,

1. Scale - Two scales are available, one with a resolution at the eye (when viewed at 18 inches) corresponding to 60 feet on the ground. The other corresponds to 20 feet. Given the relatively low contrast expected at altitude, can both scales be considered or only the larger scale/smaller field?
2. Form of "Start"- "Stop" Lines - Should the lines be semitransparent or solid, wide or narrow, single or double, black or white for maximum operator accuracy?
3. Type of "Start"- "Stop" Button - Given the operator's "suit" what kind of button should he operate to minimize reaction time error? Should he have a separate "Start" and "Stop" button?
4. Design Values - In determining final angular separation between start and stop angular measurement lines what numbers for operator performance should be used to replace the tentative numbers used in Appendix I.

#### GENERAL:

What other man-machine considerations should enter into the design shown in Appendix II.

## APPENDIX I

## V/H ALTERNATE - ERROR ANALYSIS

## Assumptions:

1. V/h .040 radians/sec. \*
2. Viewfinder measuring time 15 seconds (34° scan)

Operator Uncertainties:

	<u>TIME</u>	<u>% ERROR</u>
1. Reaction time	$\pm 1/10$ sec	$\pm 0.6\%$
2. Spatial location	$\pm 1/32''$ in 4"	$\pm 0.78\%$

## Other Known Errors:

3. Pitch during scan interval (phugoid motion)	$\pm .202^\circ$ at start and stop	$\pm 1.2\%$
4. Motor speed up and slow down uncertainty	$\pm 1/20$ sec	$\pm 0.33\%$
5. Vernistat non conformity		$\pm 0.1\%$
6. V $V_t$ signal variation		$\pm 0.2\%$
7. Variation in terrain		$\pm 0.5\%$
8. Variation in angle of attack (6.2° to 8.8°)		$\pm 0.6\%$

$$= \frac{h (\tan \theta_1 - \tan \theta_2)}{V}$$

Total R.M.S. error

 $\pm 1.5\%$ Unevaluated errors:

9. Window distortion including thermal gradients
10. Viewfinder distortion
11. Boresighting error

\* This choice is dictated by the following considerations:

1. Use 55° field of viewfinder for ease in identifying objects.
2. Allow 10° at each edge of field for acquisition and to minimize distortion.
3. Use the longest time practical to reduce effect of fixed errors.

## APPENDIX II

### ALTERNATE V/H SYSTEM

The proposed alternate V/h provides an open loop signal in the form of an A.C. voltage proportional to V/h. This output is not used in our system directly but is compared with a voltage proportional to film velocity, generating an "error signal". If film speed and last manual (viewfinder) V/h disagree by more than 3%, a "check system" light attracts the operator's attention. When the operator responds and takes a new manual reading the device automatically switches signal input. The input to our "V/h integrator" is switched from "sensor" to "alternate V/h", i.e., the above error signal. This provides a voltage controlled, closed loop V/h system instead of the normal frequency to voltage control system of the fixed grid V/h sensor.

An automatic device restores sensor control when the difference between sensor and manual V/h is under 3%. A manual override switch allows the operator to stay on manual (viewfinder) V/h control when he chooses to do so.

The above system provides:

1. An A.C. voltage proportional to viewfinder V/h.
2. A simple closed loop control.
3. Easy adaptation to other types of V/h control systems both of the closed loop error comparison type and of the open loop voltage controlled type.